Turbulence in river and maritime hydraulics

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Editorial

Turbulence in River and Maritime Hydraulics

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Abstract: Understanding of the role of turbulence in controlling transport processes is of paramount importance for the preservation and protection of aquatic ecosystems, the minimisation of deleterious consequences of anthropogenic activity, and the successful sustainable development of river and maritime areas. In this context, the present Special Issue collects 15 papers which provide a representation of the present understanding of turbulent processes and their effects in river and maritime environments. The presented collection of papers is not exhaustive but it allows for highlighting key priority areas and knowledge gaps in this field of research.

Keywords: rivers; maritime areas; turbulent processes

Introduction to the Special Issue

As the contents of this Special Issue of Water illustrate, there remains an enduring fascination with the classical topic of turbulence and the properties of turbulent flows in an environmental context. Despite of many years of investigation and many major advances, the subject continues to offer interesting and difficult research challenges. Nowhere are these challenges more prominent than in the fields of environmental fluid mechanics and environmental hydraulics, where an understanding of the role(s) of turbulence in controlling transport processes (mass, heat, solute, momentum) is crucial for the sensitive management of natural resources, the preservation and protection of aquatic ecosystems, the minimisation of deleterious consequences of anthropogenic activity, and the successful sustainable development of river and maritime areas. In order to achieve these goals, there is an urgent need for research on the fundamental properties and action(s) of turbulence to enable and guide appropriate implementation of the above objectives. Modelling investigations (analytical, laboratory, numerical) have key roles to play in this process (in conjunction with carefully-designed field measurement and monitoring campaigns), if the demands and standards of regulatory agencies are not only formulated correctly but also applied effectively. The papers contained within this issue provide an illustration of the current activity and the strength of these approaches.

The importance of recognising and understanding turbulent processes in the aquatic environment has increased with: (1) the nonlinear global economic development that has occurred in the past 50 years; (2) the recognition that such growth has the potential for (and in many cases has caused) significant negative impacts on such environments; and (3) the unrelenting social and political opposition to such consequences. These factors have taken place during a period in which energy sources have shifted and diversified and demands on water for domestic and industrial consumption have grown. All of these developments have resulted in the emergence of new and important problems in environmental fluid mechanics that rely on an understanding of turbulent processes for their amelioration or solution. In some cases, the existing research tools required to prepare responses to new external environmental threats are poorly developed or inadequate.

In the river and maritime context, recent examples are: (1) Desalination and solution mining activities to meet, respectively, water and gas storage needs, with resultant discharge of extremely high concentration brine into sensitive marine waters populated by vulnerable flora and fauna; (2) increased flood protection measures that affect sediment distributions in rivers and coastal zones and affect the state of bordering wetlands; and (3) traffic management (tunnels, bridges, harbours, etc.) that disrupt and modify established natural flow and wave conditions. A common and continued theme in this context for many years has been the pollution of the coastal marine environment as a result of anthropogenic activities associated with, for example: (1) The discharge of domestic and industrial waste water; (2) the unregulated and accidental release of petroleum and hydrocarbon products from marine traffic and offshore exploration/production installations; (3) the run-off of animal waste and fertiliser-derived nutrients from agricultural land; and (4) the construction of marine structures and waste disposal and treatment systems. All of these processes affect population health, marine ecology, economic prosperity, commercial operations, and environmental sustainability. Likewise, all of the scientific and engineering challenges associated with tackling the negative consequences require detailed knowledge of the hydrodynamic state of the affected zones. This is particularly important when it is clear that the tools available to satisfy regulatory authority guidelines may no longer be adequate for some environmental scenarios.

From a demand point of view, burgeoning interest in understanding the nature of turbulence in river and marine regions has been stimulated in recent years by: (1) The identification of numerous, previously-overlooked or previously-intractable turbulence processes controlling key environmental phenomena; (2) the recognition of the inter-connected roles of turbulent flow, sediment, vegetation, waves, boundary conditions, and the spatial and temporal distributions of contaminant sources in determining the state of the aquatic environment; and (3) the realisation of the importance of multi- and inter-disciplinary approaches to meet, target, and solve ecosystem challenges. Concurrent with the above developments, there has been significant "supply" growth in computational tools to develop new and powerful numerical modelling approaches to such problems, together with technological improvements in measurement devices for laboratory and field conditions to enable increased spatial and temporal resolution to be achieved for the distribution of key environmental parameters (e.g., velocity, vorticity, solute, contaminants, dissolved oxygen etc.) in turbulent flows relevant to the problems outlined above.

The wide-ranging survey above surely confirms that no justification is required to assess recent progress in understanding turbulence and turbulent processes through the medium of this thematic Special Issue. The constituent papers have been assembled from the work of individuals and groups of researchers working in a wide range of research areas in river and maritime environments, in order to provide a timely indication of the breadth and depth of current research effort in these areas. Not least, the contents of the papers serve to highlight key priority areas, knowledge gaps, and growth points in research activity in river, coastal, estuarine, and near-shore environments. The 15 papers contained within the Special Issue reflect the range of problems where new high quality data from laboratory and CFD (Computational Fluid Dynamics) modelling studies, and field measurements aid the interpretation of classical flow features in complex flows in: (1) Open channels, river mouths and river canyons [1–8]; (2) breaking waves and wave–current interactions in coastal zones [9–14]; and (3) gravity currents in natural channels [15]. Most significantly, the papers provide examples of where emerging problems associated with the disposal of dense brine into the aquatic environment are being tackled by detailed measurements of the turbulence properties of the flows.

The choice of papers for inclusion was dictated primarily by the timeliness of the work and the focus of the studies on turbulence and turbulent processes applicable to the chosen environmental zones. Overviews of a particular topic of research in individual areas of expertise and exposure of the current and future challenges associated with these areas were particularly encouraged. Rigorous reviewing protocols were applied in selecting the papers for inclusion.

Conflicts of Interest: The authors declare no conflict of interest.

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